ARES

Special Report No. 4

Munitions Employing Sensor-fuzed Submunitions:

Do they Comply with the Convention on Cluster Munitions?

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October 2021

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Armament Research Services

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Published in Australia by Armament Research Services (ARES).

Published in October 2021.

ISBN 978-0-6485267-9-7

Credits

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Bibliographic Information

Jenzen-Jones, N.R. 2021. *Munitions Employing Sensor-fuzed Submunitions: Do they Comply with the Convention on Cluster Munitions?* Special Report 4. Perth: Armament Research Services (ARES).

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Acknowledgements

The author offers his thanks to his colleagues at Armament Research Services, including Jack Shanley, Graeme Rice, and Tony Salvo. Thanks are also due to several confidential sources who supplied key details regarding the technical capabilities of several munitions addressed herein.

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Cover image: *Textron's Sensor Fuzed Weapon undergoing testing (source: USAF).*

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Abbreviations & Acronyms

CAS	Close air support
CCM	Convention on Cluster Munitions
DDO&S	De-spin, deceleration, orientation, and stabilisation
DoD	Department of Defense
DOT&E	Defense Operational Test and Evaluation
DPICM	Dual-purpose improved conventional munition
EFP	Explosively formed penetrator
ERA	Explosive reactive armour
GIWS	Gesellschaft für Intelligente Wirksysteme
HEAT	High explosive anti-tank
IFF	Identification, friend or foe
IFV	Infantry fighting vehicle
IR	Infrared
JTAC	Joint Terminal Attack Controller
LADAR	Laser detection and ranging
MBT	Main battle tank
MEFP	Multiple explosively formed penetrator
PGM	Precision guided munition
RHAe	Rolled homogeneous armour equivalent
SADARM	Sense and Destroy Armor
SFW	Sensor Fused Weapon
SMSgt	Senior Master Sergeant
SPBE	*Samopritselivayushchiysya Boyevoy Element* (‘self-guided submunition’)
UXO	Unexploded ordnance
WCMD	Wind Corrected Munitions Dispenser

Introduction

Several modern, anti-armour carrier munitions employ submunitions which are capable of independently identifying a target before functioning, each engaging an individual vehicle. Whilst still rare as a percentage of states' arsenals, these munitions carrying so-called 'sensor-fuzed submunitions', have been employed in a number of current and recent conflicts and are now held by a number of armed forces (Jenzen-Jones, 2017). Sensor-fuzed submunitions may be delivered by surface-to-surface missiles and rockets, artillery projectiles, or air-delivered weapons—and may be guided or unguided.[1] One submunition type can typically be delivered from multiple types of munitions with little or no modification (Wich, 2007). Although the terms 'sensor-fuzed munition' and 'sensor-fuzed weapon' are generally applied to carrier munitions, this is not a point of technical distinction—many munitions are literally sensor-fuzed, including guided missiles, anti-aircraft projectiles, and others. It is perhaps more accurate to refer to sensor-fuzed munitions as 'smart area munitions' and to specifically address sensor-fuzed submunitions ('smart submunitions' or 'terminally-sensing submunitions') separately, as these differ significantly from their traditional counterparts.

As these weapons continue to improve and proliferate, it will become increasingly relevant to determine if they are banned under the Convention on Cluster Munitions (CCW). Cluster munitions, also called 'carrier munitions' or 'cargo munitions' by specialists, are broadly characterised as munitions which are designed to disperse explosive submunitions. Whilst munitions delivering sensor-fuzed submunitions may be technically regarded as cluster munitions, they possess a range of characteristics which makes their development, acquisition, employment, effects, and post-conflict profile significantly different from those munitions more commonly referred to as such. Sensor-fuzed submunitions are generally understood as those capable of independently acquiring, identifying, and engaging a target, and—critically—not functioning the warhead if no appropriate target is identified. Sensor-fuzed submunitions are typically fitted with a self-destruction feature, and frequently with a self-deactivation feature. Speaking generally about these weapons, Textron Systems, developer of the Sensor Fuzed Weapon (SFW) munition, said "Sensor Fuzed Munitions have unique performance characteristics based on sophisticated subsystems including on-board computers, active and/or passive target detection sensors and software algorithms that detect and engage point targets; while also having self-destruct and self- deactivation features".[2]

Munitions delivering sensor-fuzed submunitions offer a number of advantages over both unitary munitions, and conventional 'dumb' submunitions. As with other cargo munitions, those delivering sensor-fuzed submunitions are, in most cases, capable of covering a much wider target area than an equivalent number of conventional munitions. Unlike conventional submunitions, they do not saturate an area target but identify and engage point targets within the target area (*Figure 2.1* shows the operational concept for these munitions). This method of functioning increases kill probability, results in fewer munitions wasted on empty space or improper targets, and results in fewer rounds having to be fired or fewer sorties flown to achieve the same result (OTA, 1987).

Munitions delivering sensor-fuzed submunitions are 'fire-and-forget' weapon systems. Once deployed, the submunitions are capable of automatically selecting and engaging targets within given parameters. This ability is further enhanced through the use of guided delivery munitions, such as the American CBU-105, formerly sold by Textron Systems.

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[1] Whilst there are other delivery methods which are feasible, these are the only methods used by munitions which have entered production.

[2] Statement from Textron Systems in McGrath, 2008.

Weapons delivering sensor-fuzed submunitions also engage targets near-simultaneously within a target area, leaving limited time for adversaries to react. The effects of these weapons can be impressive. During the advance towards Kirkuk in April 2003, the joint American-Kurdish ground forces encountered substantial resistance. There was a requirement to target multiple armoured vehicles, artillery guns, soft-skinned support vehicles, and personnel across a four-kilometre ridgeline. Senior Master Sergeant (SMSgt) John Knight, a joint terminal attack controller (JTAC) assigned to a U.S. Army Special Forces unit within Task Force Viking, called in close air support (CAS). Amongst other ordnance, he requested 16 CBU-105 munitions be employed against the targets. SMSgt Knight called the CBU-105 "the best weapon at the time for what we were looking at", and noted that the 16 CBU-105 munitions "destroyed more enemy, and took out more enemy vehicles, and took over more enemy real estate than I ever could [have] with 16 JDAMs[3], or 16 dumb bombs, and in a matter of five minutes…" (Textron, 2006). Additionally, sensor-fused submunitions are often specifically designed to present a substantially lower unexploded ordnance (UXO) risk to friendly forces, civilians, and civilian infrastructure. Indeed, Textron Systems noted that the SFW's self-destruction and self-deactivation features promote "a clean battlefield" (Textron, 2006). Similarly, Rheinmetall claims that engineers "took special care to avoid the risk of unexploded ordnance" when developing SMArt 155 artillery gun carrier projectile (Rheinmetall, 2010).

Whilst most cargo munitions employing sensor-fuzed submunitions that have entered production serve a primarily anti-armour role, some states have explored other applications for the technology. China[4] has argued that anti-ship munitions should be exempted from the CCW, and the United States also explored naval applications of SFW through the Enhanced Lethality Maritime variant of Textron's SFW (Cluster Munitions Coalition, 2011; Textron, 2014b). The United States has also briefly considered adopting the Israeli IMI M999 'advanced anti-personnel artillery carrier munition' through the Enhanced Lethality Cannon Munitions Project, before Elbit Systems discontinued the product in 2019 after acquiring IMI (Ismay, 2018; Landmine & Cluster Munition Monitor, 2021; U.S. Army, 2018). The current status of the U.S. military's interest in sensor-fuzed anti-personnel carrier munitions remains unclear. For those munitions which can readily distinguish between target types, the primary targets are main battle tanks (MBTs) and infantry fighting vehicles (IFVs). Some sensor-fuzed submunitions intended for use in the anti-armour role may also be capable of effectively engaging soft-skinned vehicles and personnel.

Operation

Carrier munitions are either dropped from an aircraft or fired from a ground or naval system towards the target area. At a pre-determined phase of the munition's flight—typically at a predetermined height above ground—the carrier munition will disperse the submunitions or their containers. The descent of these munitions is commonly slowed using various methods, most often a ballute or parachute, before descending towards the target area. Sensor-fuzed submunitions in current production use either a parachute or a wing structure to stabilise their descent. Whilst parachutes permit a simpler design and provide a beneficially slow rotational speed, the decreased rate of descent could result in a longer reaction time for enemy forces. Additionally, parachute-stabilised submunitions are more susceptible to adverse wind conditions (He, Yang & Zhang, 2016; Nicolle & Torrence, 2003). Once the parachute or stabilising wings have deployed, the

[3] Joint Direct Attack Munition, a 'bolt-on' guidance kit that converts an unguided aerial munition to a precision guided munition (Jenzen-Jones, 2015a).

[4] Note that, although not covered herein, China has developed several sensor-fuzed submunitions, including an unguided artillery projectile which delivers two sensor-fuzed submunitions (translated as 'terminally-sensing submunitions' and described in English as 'Terminally Sensing Ammunition'; TSA), a 302 mm rocket, and a 320 mm rocket (Cluster Munition Monitor, 2020; Lee, 2012). Assuming these munitions are fitted with a self-deactivating mechanism, they would most likely be permitted under the CCM. China has also reportedly equipped its DF-16B ballistic missile with sensor-fused submunitions, but little is known about this weapon system (Lin & Singer, 2016).

submunition enters a nutational rotation oblique to the natural axis of the warhead, creating a helical search pattern that becomes smaller and more focused as the submunition descends (see *Figure 2.1*) (Dullum, 2007).

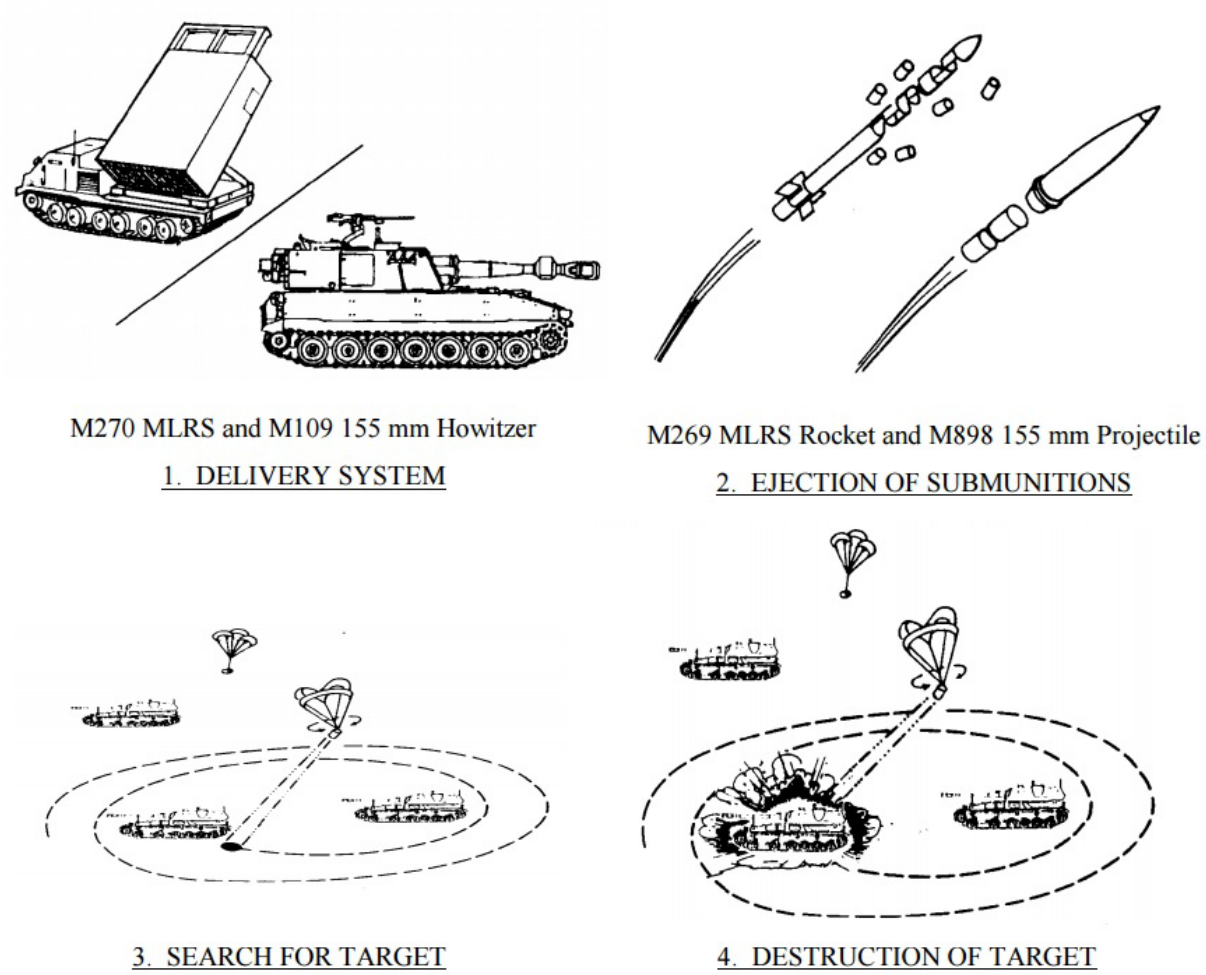

Figure 2.1 *Operational concept for munitions delivering sensor-fuzed submunitions (source: GAO).*

Sensor-fuzed submunitions use a variety of methods to identify targets. Many models feature single-, dual-, or multi-band infrared (IR) sensors, which sense and evaluate the infrared contrasts from the target search area, separating the target from the background and non-target objects. Other sensors may include laser detection and ranging (LADAR) sensors, acoustic sensors, active millimetre wave radar, and passive millimetre wave radar (radiometer).

To function the warhead, the target must generate a signal which matches target profiles programmed into the munition. The process of matching potential targets to these profiles is more precise when multiple types of modern, high-fidelity sensors are employed. For the submunitions carried by the 155 BONUS MK II to function, for example, potential targets must exhibit an appropriate 3D profile, as determined by the LADAR unit, as well as a corresponding signal in the main IR band. An object which has a 3D signature which is too high, too low, or too wide is classified as a non-target, and will not function the munition. Similarly, an object generating an IR signature which is outside of the target profile will not be engaged (see *Figure 2.2*) (Bofors, n.d.).

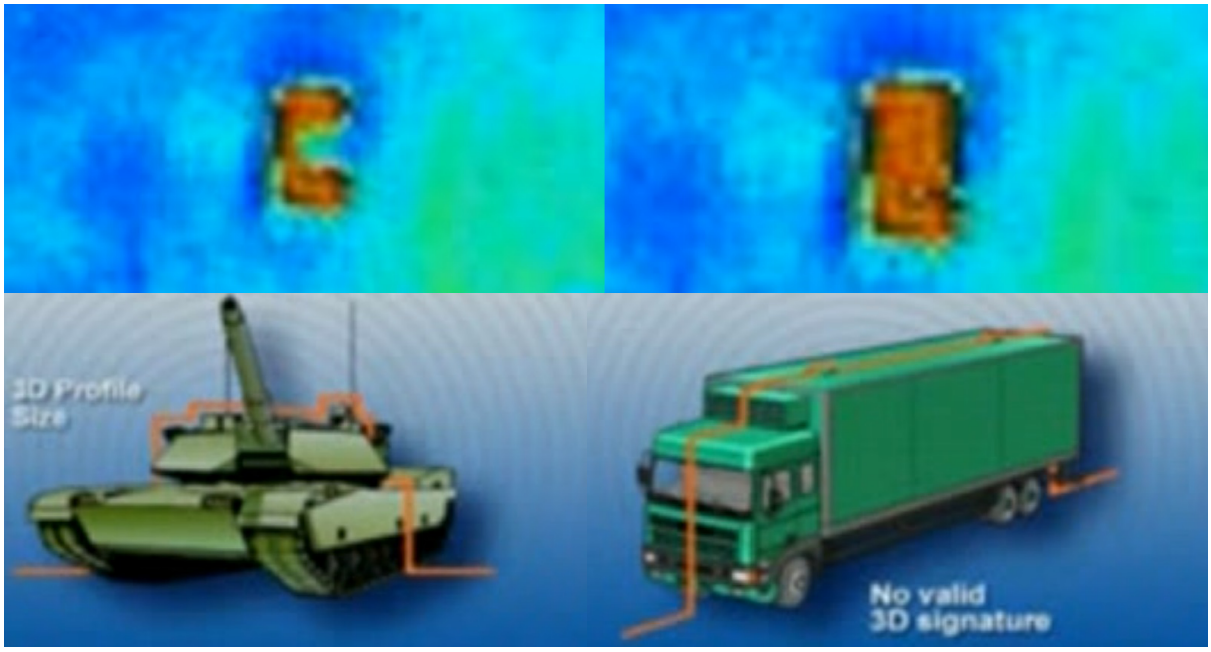

Figure 2.2 *Infrared and laser scanner profiles as determined by the 155 BONUS MK II submunition (source: Bofors, n.d.).*

Whilst recent models are more capable of distinguishing between military and civilian vehicles, the older examples still in service have only a limited ability to differentiate between these potential targets (GICHD, 2009). This target profiling process serves not only to mitigate collateral concerns, but also seeks to ensure that these expensive, specialised munitions target the targets of the most military value—i.e., MBTs and IFVs—within the target search area. It is important to note that different munitions will have different requirements for target profile matching; some may be intended to engage a wider range of targets, including soft-skinned vehicles or personnel.

Most sensor-fuzed submunitions employ explosively formed penetrator (EFP)[5] warheads. The EFP is formed by the dynamic deformation of a concave metallic liner due to the detonation of an explosive charge located behind it (Hazell, 2015, pp. 74–75). The dish-shaped liner is, in effect, folded in on its central point to form a pointed 'slug' (see *Figure 2.3*). EFP warheads are a subset of shaped-charge warheads, and also feature metal liners. They are differentiated from conventional high explosive anti-tank (HEAT) shaped charges—the liners of which are explosively deformed to generate a high-speed metal 'jet'—by instead producing a slower-moving metallic 'slug' (Cross et al., 2016, pp. 22–23; Hazell, 2015, pp. 68–75). EFPs are commonly formed from copper liners, however other metals including iron, aluminium, and tantalum have also been employed (Morrison et al., 2015; Hazell, 2015, pp. 74–75).

EFPs typically reach velocities in excess of 2 km per second,[6] and provide substantial armour penetration given the size of the munition and the range of engagement (Walters, 2007). Unlike conventional HEAT warheads, which have a standoff range measured in centimetres, EFPs are generally able to engage targets from tens or hundreds of metres. EFPs formed by sensor-fuzed submunitions are of the 'long rod' type, optimised for armour penetration. [7]

[5] Sometimes also referred to as 'explosively formed projectile' or 'self-forging fragment' warheads.

[6] By way of comparison, conventional HEAT shaped charges generate 'jets' of material travelling at hypervelocity. The tip of such a jet may travel at velocities in excess of 10 km/s (Walters, 2007).

[7] 'Short rod' EFPs—those where the EFP has a shorter, broader profile—are preferred for demolition tasks.

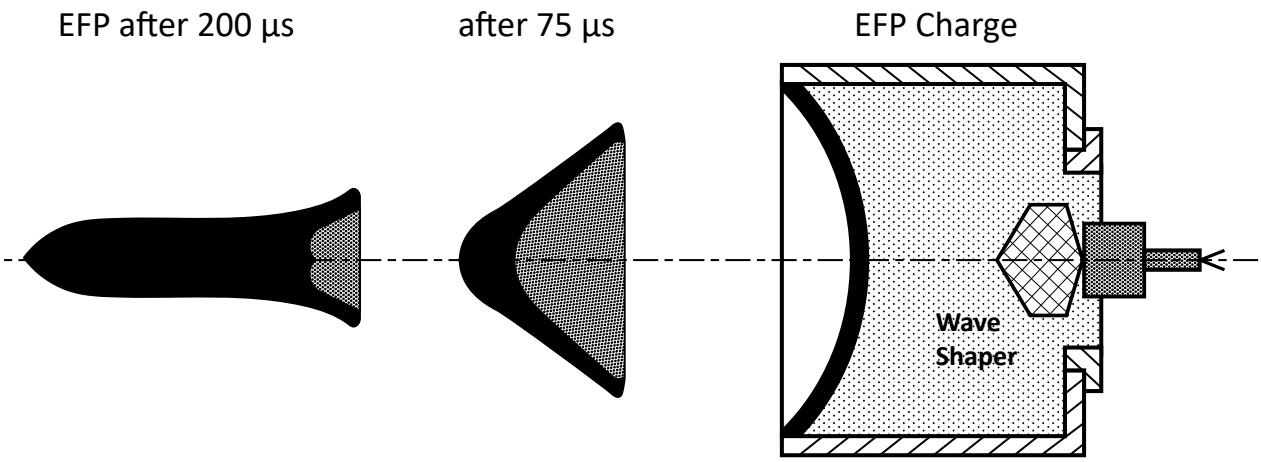

Figure 2.3 *A typical explosively formed penetrator (EFP) and charge (source: ARES after Walters, 2007).*

Existing sensor-fuzed submunition designs rely on elevated attack geometry to engage the area of the target which is typically fitted with the weakest armour. This 'top-attack' behaviour allows for smaller, lighter munitions to be employed. EFPs are harder to counter than conventional HEAT warheads, posing a challenge for explosive reactive armour (ERA) (Hazell, 2015; OTA, 1987). Some sensor-fuzed submunitions, notably the 'smart skeets' of the BLU-108, make use of multiple explosively formed penetrator (MEFP) warheads, which are designed to produce several EFP slugs or fragments for increased effectiveness against dispersed targets, including personnel and soft-skinned vehicles.

As noted, most sensor-fuzed submunitions contain self-destruction mechanisms, and many contain self-deactivation (also called 'self-neutralisation' or 'safe-and-disarm') mechanisms. Unexploded ordnance (UXO) poses a hazard not only to civilians, but also to follow-on troops who may be advancing through an area, and to EOD personnel who are responsible for neutralising UXO during or after a conflict. During the First Gulf War, at least 25 U.S. military personnel were killed by submunition UXO (GAO, 1993). Most sensor-fuzed submunitions feature a pyrotechnic self-destruct mechanism, and some also feature an electronic self-destruct mechanism. The self-deactivation method is most commonly effected by employing a battery with a limited lifespan, which is only activated when the submunition is deployed from its carrier and/or a mechanism to short-circuit the battery upon impact (Dullum, 2007). Whilst these mechanisms do not make the UXO left by sensor-fuzed submunitions inherently safe, they do minimise the possibility of the submunitions functioning through disturbance or handling.

Assessing CCM Compliance

This report briefly examines five common carrier munitions which dispense sensor-fuzed submunitions: the Sensor-Fuzed Weapon (SFW), produced by Textron Systems in the United States; the SMArt 155, produced by GIW in Germany; the RBK-500 SPBE, produced by NPO Bazalt in Russia; the M898 SADARM, produced by Aerojet in the United States; and the 155 BONUS, produced by BAE Systems Bofors of Sweden and Nexter Munitions of France. These are only some of the weapons in production or service today—this report does not seek to present a comprehensive list of munitions which dispense sensor-fuzed submunitions. The BLU-108, RBK-500 SPBE, and M898 SADARM have been used in combat operations, whilst the SMArt 155 and 155 BONUS have not.

Most specialists would agree that, speaking purely to their technical characteristics, all of these weapons are properly classified as carrier, or cluster, munitions by virtue of dispensing explosive submunitions. However, this technical distinction does not translate directly to the definition of 'cluster munitions' as codified within the Convention on Cluster Munitions (CCM), which deliberately excludes certain munitions employing sensor-fuzed submunitions. When examining whether or not a specific munition is to be considered a 'cluster munition' under the CCM, Articles 1 and 2 must be consulted. Article 1 should be considered in full, and is reproduced below:

1. *Each State Party undertakes never under any circumstances to:*
    a. *Use cluster munitions;*
    b. *Develop, produce, otherwise acquire, stockpile, retain or transfer to anyone, directly or indirectly, cluster munitions;*
    c. *Assist, encourage or induce anyone to engage in any activity prohibited to a State Party under this Convention.*
2. *Paragraph 1 of this Article applies, mutatis mutandis, to explosive bomblets that are specifically designed to be dispersed or released from dispensers affixed to aircraft.*
3. *This Convention does not apply to mines.*

Within Article 2, Clauses 2, 3, 9, and 10 are especially applicable, and Clauses 12, 13 and 14 must also be considered.

2. *"Cluster munition" means a conventional munition that is designed to disperse or release explosive submunitions each weighing less than 20 kilograms, and includes those explosive submunitions. It does not mean the following:*
    a. *A munition or submunition designed to dispense flares, smoke, pyrotechnics or chaff; or a munition designed exclusively for an air defence role;*
    b. *A munition or submunition designed to produce electrical or electronic effects;*
    c. *A munition that, in order to avoid indiscriminate area effects and the risks posed by unexploded submunitions, has all of the following characteristics:*
        i. *Each munition contains fewer than ten explosive submunitions;*
        ii. *Each explosive submunition weighs more than four kilograms;*
        iii. *Each explosive submunition is designed to detect and engage a single target object;*
        iv. *Each explosive submunition is equipped with an electronic self-destruction mechanism;*
        v. *Each explosive submunition is equipped with an electronic self-deactivating feature;*
3. *"Explosive submunition" means a conventional munition that in order to perform its task is dispersed or released by a cluster munition and is designed to function by detonating an explosive charge prior to, on or after impact;*
9. *"Self-destruction mechanism" means an incorporated automatically functioning mechanism which is in addition to the primary initiating mechanism of the munition and which secures the destruction of the munition into which it is incorporated;*
10. *"Self-deactivating" means automatically rendering a munition inoperable by means of the irreversible exhaustion of a component, for example a battery, that is essential to the operation of the munition;*

12. *"Mine" means a munition designed to be placed under, on or near the ground or other surface area and to be exploded by the presence, proximity or contact of a person or a vehicle;*
13. *"Explosive bomblet" means a conventional munition, weighing less than 20 kilograms, which is not self-propelled and which, in order to perform its task, is dispersed or released by a dispenser, and is designed to function by detonating an explosive charge prior to, on or after impact;*
14. *"Dispenser" means a container that is designed to disperse or release explosive bomblets and which is affixed to an aircraft at the time of dispersal or release;*

In order to be considered a cluster munition under the CCM, a munition must exhibit a certain series of characteristics, and lack other characteristics. The questions that should be asked in order to determine whether or not a given munition is a cluster munition under the CCM can be distilled into a nine-step test, as follows:

1. *Does the munition in question disperse or release submunitions or 'bomblets'?*
2. *Are these submunitions or bomblets designed to function by detonating an explosive charge prior to, on, or after impact?*
3. *Is the munition or its submunitions or bomblets using an explosive charge in a manner designed to dispense flares, smoke, pyrotechnics, or chaff, or to generate electrical or electronic effects?*
4. *Is the munition designed exclusively for an air defence role?*
5. *Does the munition contain fewer than ten explosive submunitions or explosive bomblets?*
6. *Do each of the explosive submunitions or explosive bomblets weigh more than four kilograms, but less than twenty?*
7. *Is each explosive submunition or explosive bomblet designed to detect and engage a single target object?*
8. *Is each explosive submunition or explosive bomblet equipped with an electronic self-destruction mechanism?*
9. *Is each explosive submunition or explosive bomblet equipped with an electronic self-deactivating feature?*

These questions are examined on a munition-by-munition basis, along with a general description of each munition's function, below. *Figure 3.1* presents this nine-step test in a flowchart format. Table 5.1 shows the answers to each of these questions for the five munitions examined in this report.

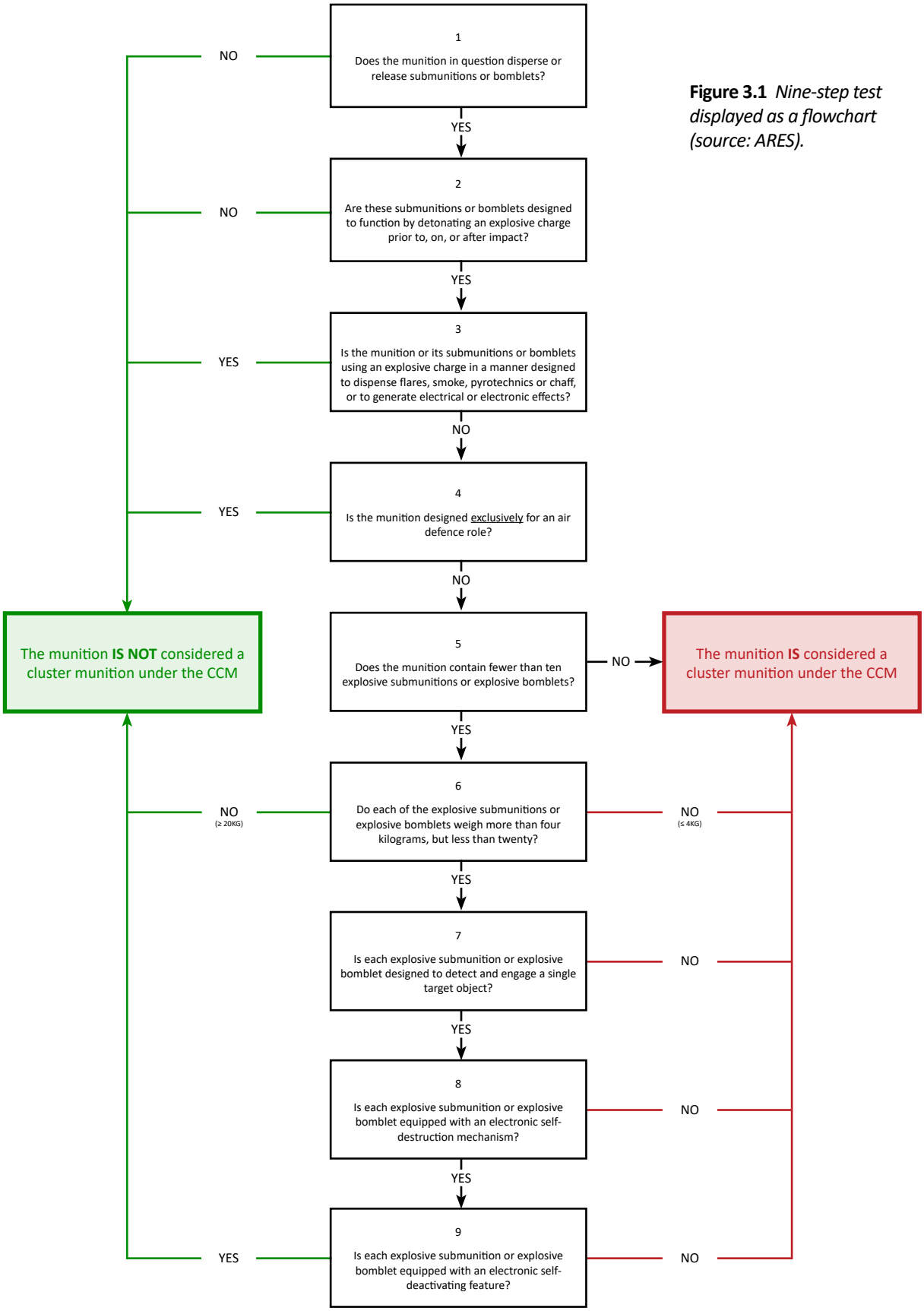

Figure 3.1 *Nine-step test displayed as a flowchart (source: ARES).*

Analysis of Selected Munitions

Sensor-Fuzed Weapon (SFW)

Overview

The Textron Systems Sensor-Fuzed Weapon (SFW), best known by its U.S. Air Force designation CBU-97 or CBU-105 (see below), is an air-delivered cargo munition developed by Textron Systems in partnership with the United States Air Force. Patents for submunitions used by this system date back to at least 1979 (Avco Corp, 1979). It entered production in 1992, and was used in combat during Operation Iraqi Freedom in 2003 (Textron, 2015). Whilst the U.S. Air Force 'CBU' designation stands for 'Cluster Bomb Unit', these weapons are substantially different to conventional cluster munitions.

The CBU-97 is available with Wind Corrected Munitions Dispenser (WCMD) series modification kits which convert it to a precision guided munition (PGM),[8] redesignated as the CBU-105. Whilst the 26 m (85 ft) CEP of the WCMD is lower than some other PGMs in service with developed armed forces, it is more than sufficient to deliver submunitions designed for area coverage, such as the BLU-108.

Each SFW contains ten BLU-108 submunitions, sometimes referred to as 'posts'. Each post contains an additional four submunitions. When the munition functions, the dispenser panels are separated by a linear bursting charge, before the BLU-108 submunitions are ejected from the munition by a gas bag ejection system. The five submunitions contained in the forward bay are ejected first, shortly followed by the five in the aft bay. A drogue parachute precedes a main parachute, which brings the BLU-108 to a vertical position. When the munition has descended to the correct height above the ground, the parachute is released and the four "smart Skeet warhead" submunitions pivot into an exposed position (Textron, 2014a).

A rocket motor within the BLU-108 then initiates, imparting spin to the submunition. The BLU-108 halts descent and begins to climb. The individual Skeet submunitions are then released, and spin rapidly whilst descending, searching within their own target areas. The target is identified using a combination of passive IR and active laser sensors. Once a target that meets the targeting parameters has been acquired, the warhead functions (Textron, 2014a; 2015).

The Skeet submunitions each feature a sub-type of MEFP warhead. In this case, the copper liner features a central concave area forming the primary EFP, surrounded by a ring of sixteen smaller indentations which form smaller EFPs. This configuration is sometimes referred to as a 'combined effects EFP' and serves to allow for wider lethal areas against soft-skinned vehicles and personnel in the vicinity of the primary target (Fong, 2000). A 'true' MEFP warhead that does not feature a primary penetrator was also developed for the Enhanced Maritime Lethality variant (Textron, 2014b).

The Skeet submunitions require the BLU-108 post to arm, and cannot arm independently. If, for example, a BLU-108 submunition were to fail to function and crash intact, the Skeet submunitions would not have armed, as they would not have proceeded through the requisite mechanical and electrical processes. The BLU-108 submunition must spin at the correct rate before the explosive bolts releasing the Skeet submunitions are able to function. The Skeets then continue to spin, and require a certain amount of centripetal force in order to arm.[9]

[8] The term 'precision guided munition' applies broadly to any munitions which can "alter their flights paths to strike a target with a high degree of precision" (Shanley & Jenzen-Jones, 2021).

[9] Interview with confidential source.

If a Skeet submunition does not detect a valid target during its flight time, one or more of its three safety modes will activate. The Skeet will self-destruct after either 8 seconds of launch, or when it reaches an elevation of approximately 15 m (50 ft) above the ground. Should these self-destruct mechanisms not function, a battery time-out device will render the submunition "inert within minutes" of hitting the ground (Textron, 2015).

Nine-Step Assessment

1. **Yes.** The SFW is an air-delivered cargo munition that releases submunitions.
2. **Yes.** The submunitions released by the SFW function by detonating an explosive charge prior to impact.
3. **No.** Neither the SFW, nor the BLU-108 or Skeet submunitions, are designed to dispense smoke, pyrotechnics or chaff, or to generate electrical or electronic effects.
4. **No.** The SFW is used primarily in an anti-armour role.
5. **No.** The SFW contains 40 explosive Skeet submunitions.
6. **No.** Each Skeet submunition weighs approximately 3.4 kilograms.
7. **Yes.** Each Skeet submunition is designed to detect and engage a single target object.[10]
8. **Yes.** Each Skeet submunition is equipped with an electronic self-destruction mechanism.
9. **Yes.** The BLU-108 and Skeet submunitions are equipped with electronic self-deactivating features.

*Thus, the Textron Systems SFW **does** constitute a 'cluster munition' as defined under the CCM.*

Whilst these skeets are not considered submunitions by Textron, they fall within the definition of an 'explosive submunition' given in the CCM, in that "in order to perform [their] task [they are] dispersed or released by a cluster munition and [are] designed to function by detonating an explosive charge prior to, on or after impact". The BLU-108 submunition further constitutes a cluster munition under the CCM, being a "conventional munition that is designed to disperse or release explosive submunitions each weighing less than 20 kilograms" and meeting the nine-step test presented in this report, independently of its carrier munition.

Some U.S. proposals have examined an air-delivered single BLU-108, independent of the SFW carrier munition. This configuration would still not meet CCM requirements, as each Skeet submunition weighs less than four kilograms. The BLU-108 itself, despite being a submunition in technical terms when released from the SFW, likely does not constitute a submunition under the CCM. Whilst the BLU-108 does feature explosive bolts used to separate the Skeets from the munition, one may argue this is not what is meant by "designed to function by detonating an explosive charge prior to, on, or after impact".[11] As such, if a variant of the Skeet submunitions which weighed more than 4 kg were produced the BLU-108 munitions containing these would not be considered a cluster munition under the CCM.

[10] However, each Skeet submunition generates multiple EFPs, potentially engaging multiple targets with each submunition.

[11] A submunition dispensing propaganda leaflets, for example, often relies on the detonation of an explosive charge to function.

Technical Specifications – SFW (CBU-105)

Total weight: 427 kg
Overall length: 2300 mm
Diameter: 400 mm
Number of submunitions: 10 BLU-108 submunitions

Figure 4.1 *Textron Systems Sensor Fuzed Weapon, with cutaway panel showing BLU-108 submunitions (source: Bloomberg).*

Technical Specifications – BLU-108

Total weight: 29 kg
Length: 790 mm
Diameter: 133 mm
Number of submunitions:
4 Skeet submunitions

Figure 4.2 *Textron Systems BLU-108 'post' submunition, with four Skeet submunitions exposed, prior to release (source: Textron Systems).*

Technical Specifications – Skeet submunition
Total weight: 3.4 kg
Length: 95 mm
Diameter: 127 mm
Sensors: dual-band IR; LADAR

Figure 4.3 *Skeet submunition documented near al-Amar in Yemen, 2015 (left) and functioning stages of the Skeet EFP warhead (right). Note the 16 smaller 'fragments' surrounding larger central EFP (sources: HRW; Bloomberg).*

Suchzünder Munition für die Artillerie 155 (SMArt 155)

Overview

The *Suchzünder Munition für die Artillerie 155* (SMArt 155) is an unguided artillery gun carrier projectile that dispenses two sensor-fuzed submunitions. It is produced in Germany by Gesellschaft für Intelligente Wirksysteme (GIWS) mbH, a joint venture between Diehl BGT Defence GmbH & Co. KG and Rheinmetall Waffe Munition.[12] The SMArt 155 projectile entered development in 1989, and was fielded by the German Army at the turn of the century under the designation DM 702 (submunition: DM 1489). Later product improvements have seen the introduction of the DM 702A1, and further development is understood to be underway. According to a March 2002 memo to Donald Rumsfeld, then the U.S. Secretary of Defense, 1,600 SMArt 155 rounds could have been purchased by and delivered to the United States by the end of 2002 for an estimated unit price of fifty to sixty thousand USD (Aldridge, 2002). Ultimately, the U.S. did not acquire the munition. The SMArt 155 is in service with forces in Australia, Germany, Greece, and Switzerland (GIWS, n.d.).

[12] Each company holds a 50% share (Ness & Williams, 2011).

The SMArt 155 projectile is fired from conventional 155 mm artillery systems. At a given phase in its trajectory, the two submunitions are ejected from the base of the projectile. The speed of the submunitions is reduced by ballutes, before parachutes unfurl to provide a stable descent. During the descent phase, the electro-optical unit is deployed and the submunition searches for targets within a helical search pattern which decreases as the submunition descends. The electro-optical unit uses passive IR and both active and passive millimetre wave radar to detect potential targets and develop a target signature within a search area of 35,000 square metres (Valcourt, 2004). Once a suitable target is located, the submunition functions and engages the target with its unitary EFP warhead, which features a tantalum liner (Wich, 2007).

If the SMArt submunition does not identify a target which conforms to its targeting profiles before it descends to a given elevation, it will initiate a self-destruct function. Both pyrotechnic and electronic self-destruct functions are present in the SMArt, a redundant battery burnout self-deactivation feature is activated should self-destruction fail to occur. During testing, the SMArt submunition reportedly displayed a resistance to an array of countermeasures and effective operation under various environmental conditions (Valcourt, 2004).

There is believed to be an MEFP or APERS warhead developed for the SMArt 155, but details on this remain unclear (Ness & Williams, 2011). SMArt submunitions have also been integrated into GMLRS rockets, with each rocket carrying four submunitions (GIWS, n.d.). More than 20,000 SMArt submunitions have been produced (Wich, 2007).[13] GWIS has recently announced a Phase 4 production run of the SMArt 155 to replenish German Army stockpiles, with manufacturing scheduled to begin in 2024 (Foss, 2019).

Nine-Step Assessment

1. **Yes.** The SMArt 155 is an artillery gun carrier projectile that releases submunitions.
2. **Yes.** The submunitions released by the SMArt 155 function by detonating an explosive charge prior to impact.
3. **No.** Neither the SMArt 155, nor its SMArt submunitions, are designed to dispense smoke, pyrotechnics or chaff, or to generate electrical or electronic effects.
4. **No.** The SMArt 155 is used primarily in an anti-armour role.
5. **Yes.** The SMArt 155 contains two explosive submunitions.
6. **Yes.** Each SMArt submunition weighs approximately 6-7 kg.
7. **Yes.** Each SMArt submunition is designed to detect and engage a single target object.
8. **Yes.** Each SMArt submunition is equipped with an electronic self-destruction mechanism.
9. **Yes.** Each SMArt submunition is equipped with an electronic self-deactivating feature.

Thus, the GIWS SMArt 155 ***does not*** *constitute a 'cluster munition' as defined under the CCM.*

Technical Specifications – SMArt 155
Total weight: 47.3 kg
Overall length: 898 mm
Diameter: 155 mm
Number of submunitions: 2

[13] IHS Jane's has reported that the original production run consisted of more than 12,000 SMArt 155 munitions (Foss, 2019).

Figure 4.4 *Cutaway SMArt 155 projectile showing submunitions within the carrier munition and an additional submunition with deployed ballute (source: N.R. Jenzen-Jones/ARES).*

Technical Specifications – SMArt submunition
Total weight: 36.0–37.0 kg
Length: 180–200 mm
Diameter: 140–150 mm[14]
Sensors: multi-band IR; millimetre wave radar; radiometer

Figure 4.5 *SMArt 155 projectile and submunition (left) and SMArt submunition (right) (source: GIWS).*

[14] Values estimated for submunition.

RBK-500 SPBE-D

Overview

The RBK-500 SPBE series of munitions were developed by JSC NPO Bazalt in the 1980s, with designers seeking to produce a munition capable of engaging multiple armoured vehicles simultaneously. This work was awarded the State Prize of the USSR in 1991. The RBK-500 SPBE series is similar in role to the SFW with its BLU-108 submunitions. The RBK-500 SPBE is an unguided cluster bomb, however a GLONASS-guided variant known as the RBK-500U SPBE series has been developed by Rostec Corporation's Tekhmash Concern in more recent years (Karnozov, 2006; Tekhmash, 2018).

Each RBK-500 SPBE series munition contains 15 *Samopritselivayushchiysya Boyevoy Element* (SPBE; 'self-guided submunition') submunitions.[15] The early SPBE model was succeeded by the later SPBE-D and SPBE-K models. The original SPBE submunitions use IR seekers to target armoured fighting vehicles. The later model SPBE-D submunition employs a dual-mode IR seeker, whilst the SPBE-K also includes a radio frequency sensor and millimetre wave radar. The latest submunitions can be operated in conjunction with an identification, friend or foe (IFF) system (Jenzen-Jones & Lyamin, 2015).[16]

The cargo munition functions after a predetermined time delay, ejecting the parachute-equipped submunitions. These spin in a controlled fashion, sweeping the area below for targets. Upon functioning, the SPBE series submunitions fire an explosively formed penetrator (EFP), which is believed to be capable of penetrating approximately 70 mm of rolled homogeneous armour equivalent (RHAe) at an angle of 30 degrees, from a distance of 100 m. The technical specifications for the RBK-500 SPBE-D—believed to be very similar to the standard model—as well as the SPBE submunition are given below. The later SPBE series submunitions are known to have a self-destruct function. The latest variant, the SPBE-K, is described by the developer as being resistant to "natural and artificial interference" and has an electronic safe-and-disarm function (Tekhmash, 2018).

Nine-Step Assessment

1. **Yes.** The RBK-500 SPBE is an air-delivered cargo munition that releases submunitions.
2. **Yes.** The submunitions released by the RBK-500 SPBE function by detonating an explosive charge prior to impact.
3. **No.** Neither the RBK-500 SPBE, nor the SPBE submunitions, are designed to dispense smoke, pyrotechnics or chaff, or to generate electrical or electronic effects.
4. **No.** The RBK-500 SPBE is used primarily in an anti-armour role.
5. **No.** The RBK-500 SPBE contains fifteen explosive submunitions.
6. **Yes.** Each RBK-500 SPBE submunition weighs approximately 17.3 kilograms.
7. **Yes.** Each SPBE submunition is designed to detect and engage a single target object.
8. **Yes.** The SPBE submunitions are equipped with an electronic self-destruction mechanism.
9. **Yes.*** The later SPBE-series submunitions are equipped with electronic self-deactivating features, however this has not been confirmed.

*Thus, the NPO Bazalt RBK-500 SPBE **does** constitute a 'cluster munition' as defined under the CCM, regardless of whether or not the submunitions are fitted with an electronic safe and disarm feature.*

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[15] Previously known under the designation 'Мотив-3М' (*Motiv-3M*).

[16] SPBE-series submunition can also be dispensed from the 300 mm 955K1 rocket, which carries five SPBE-D submunitions and is fired from the 9K58 *Smerch* multiple-barrelled rocket launcher (Jenzen-Jones & Lyamin, 2015).

Technical Specifications – RBK-500 SPBE-D
Total weight: 500 kg
Overall length: 2,485 mm
Diameter: 450 mm
Number of submunitions: 15

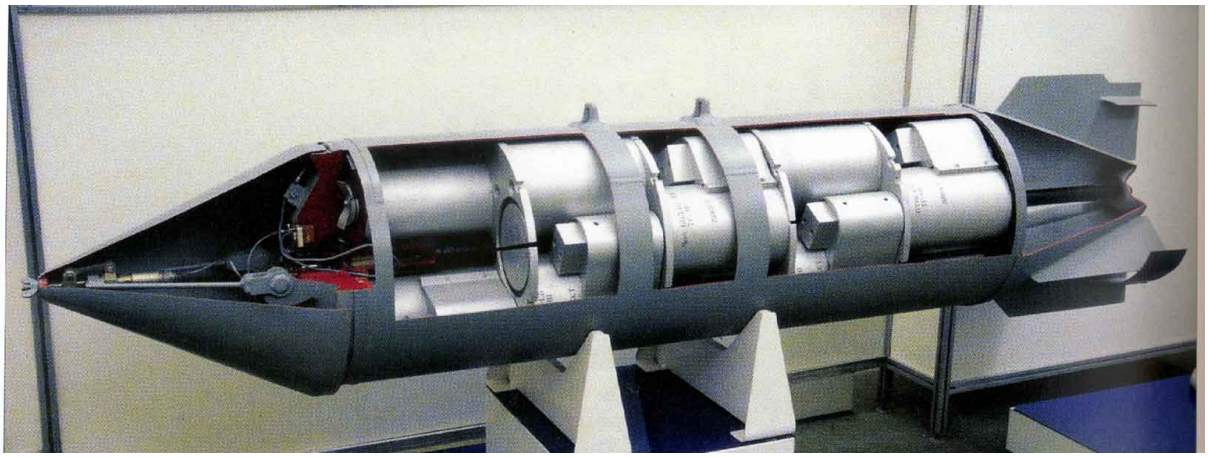

Figure 4.6 *Russian RBK-500 SPBE air-delivered cargo munition (original source unknown).*

Technical Specifications – RBK-500U SPBE-K
Total weight: 540 kg
Overall length: 3,100 mm
Diameter: 450 mm
Number of submunitions: 15

Figure 4.7 *Russian RBK-500U SPBE-K air-delivered guided cargo munition (source: TASS).*

Technical Specifications – SPBE
Total weight: 17.3 kg
Length: 384 mm
Diameter: 185 mm

Figure 4.8 *Russian SPBE-series sensor-fuzed submunitions in Syria, October 2015. This example did not function. (source: Jenzen-Jones & Lyamin, 2015).*

M898 SADARM

Overview

The M898 Sense and Destroy Armor (SADARM) is an unguided artillery gun-fired carrier projectile that dispenses two sensor-fuzed submunitions. It was formerly produced in the United States by GenCorp Aerojet, and later by Northrop Grumman. The concept that would be developed into the SADARM submunition was born in the 1970s as part of the U.S. Assault Breaker Program (Newbery, 2008). Work thus conducted on the 203 mm XM836 SADARM formed the basis of development for the M898 SADARM projectile from 1984 onwards.

Upon ejection from its carrier projectile over the target area, each submunition deploys a two-stage device known as the de-spin, deceleration, orientation, and stabilisation (DDO&S) mechanism, which features both a ram-air ballute and a vortex ring parachute. This steadies and stabilises the munition, and ensures a constant rotational rate. As the submunition falls and rotates, it searches the ground with dual-band IR and active and passive millimetre wave sensors at an angle of 30° off vertical. If a target matching the parameters programmed into the munition is located, the submunition fires a tantalum EFP at the target. If no suitable target is detected, self-destruct and deactivation features are initiated (DoD, 1999).

The U.S. Army terminated procurement of the M898 SADARM projectile in Fiscal Year 2000, largely due to issues with submunition reliability and cost (DoD, 1999). The first combat employment of this system was by the U.S. Army in Iraq in 2003 (Aldridge, 2002; Nicolle & Torrence, 2003). During the campaign, 108 rounds were fired—accounting for 48 vehicle kills (Nicolle & Torrence, 2003). Early generation SADARM munitions were theoretically vulnerable to a range of countermeasures, and were more significantly affected by adverse weather conditions or cluttered backgrounds (Flachs et al., 1990).

According to a March 2002 memo to Donald Rumsfeld, then the U.S. Secretary of Defense, there were 348 ready-to-use M898 SADARM projectiles in the U.S. inventory at that time. Additional production costs were estimated at a unit price of 50,000–60,000 USD (Aldridge, 2002). SADARM submunitions were also tested in a range of other weapon systems, including rockets, missiles, and mortar projectiles.

Nine-Step Assessment

1. **Yes.** The M898 SADARM is an artillery gun carrier projectile that releases submunitions.
2. **Yes.** The submunitions released by the M898 SADARM function by detonating an explosive charge prior to impact.
3. **No.** Neither the M898 SADARM, nor its SADARM submunitions, are designed to dispense smoke, pyrotechnics or chaff, or to generate electrical or electronic effects.
4. **No.** The M898 SADARM is used primarily in an anti-armour role.
5. **Yes.** The M898 SADARM contains two explosive submunitions.
6. **Yes.** Each SADARM submunition weighs approximately 13.6 kg.
7. **Yes.** Each SADARM submunition is designed to detect and engage a single target object.
8. **Yes.** Each M898 SADARM submunition is equipped with an electronic self-destruction mechanism.
9. **Yes.** Each M898 SADARM submunition is equipped with an electronic self-deactivating feature.

*Thus, the Aerojet M898 SADARM **does not** constitute a 'cluster munition' as defined under the CCM.*

Technical Specifications – M898 SADARM
Total weight: 47 kg
Overall length: 898 mm
Diameter: 155 mm
Number of submunitions: 2

Figure 4.9 *An M898 SADARM projectile cutaway to show submunitions (source: U.S. Army).*

Technical Specifications – SADARM submunition

Total weight: 13.6 kg
Overall length: 175 mm
Diameter: 147 mm
Sensors: dual-band IR; millimetre wave radar; radiometer

Figure 4.10 *A SADARM submunition which failed to function in Iraq in 2003 (source: Peter Bouckaert/HRW).*

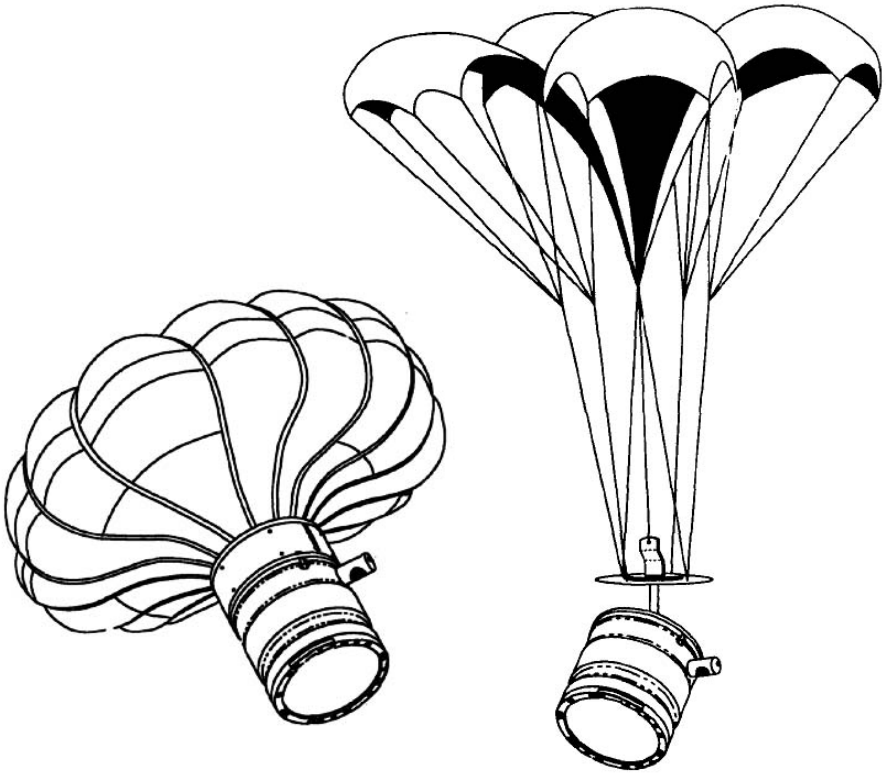

Figure 4.11 *A diagram showing SADARM submunition parachutes (source: U.S. Army).*

155 BONUS

Overview

The 155 BONUS is an unguided artillery gun carrier projectile that dispenses two sensor-fuzed submunitions. It was formerly produced by Bofors Defence and GIAT Industries, and is now offered by BAE Systems Bofors of Sweden and Nexter Munitions of France. Work on BONUS began in the early 1980s, with the Swedish and French militaries acquiring the first munitions in the early 2000s. Development of the BONUS Mk II began in 2001, adding LADAR and modernised electronics, and development of the Mk III was announced in 2007. The Mk III is intended to incorporate a remote-firing command capability. According to a March 2002 memo to Donald Rumsfeld, 800 155 BONUS rounds could have been purchased and delivered by mid-2003 for an estimated unit price of 25,000–35,000 USD (Aldridge, 2002). The U.S. ultimately purchased the munition, most recently purchasing additional rounds through the NATO Support and Procurement Agency in early 2020. Today, Finland, France, Norway, Sweden, and the United States maintain inventories of 155 BONUS ammunition (BAE Systems, 2020).

The 155 BONUS projectile is fired from conventional 155 mm artillery systems. Once the projectile is some 800–2,200 m above the target area, two container cylinders are ejected from the base of the projectiles. These reduce the velocity and rotation of the submunitions and ensure correct orientation. The submunitions are then expelled from the cylinders and wings unfold to stabilise the submunitions. Its asymmetrically-fixed wings give the BONUS submunition a high spin rate (15 revolutions per second), and allow for a rapid descent of 45 m/s. This results in stable flight, low sensitivity to wind, and a lower reaction time for enemy forces (Gerhardsson, 2002).

The electro-optical sensor is then deployed and the warhead is armed. This varies according to the generation of the munition. The BONUS Mk 1 features a multi-band IR sensor package, whilst the MK II also incorporates a laser profile detector (Bofors, n.d.). The electro-optical unit uses dual-band passive IR and, in the MK II, a LADAR (profile detector) to detect potential targets and develop a target signature within a search area of 32,000 M^2, which is covered rapidly—in less than four seconds (Bofors, n.d.; Valcourt, 2004). If a suitable target is detected, the EFP warhead with a tantalum liner functions. The EFP travels at more than 2 km/s and can penetrate more than 130 mm of armour, from a standoff distance of up to 200 m (Bofors, n.d.; Gerhardsson, 2002). If no suitable target is detected after a given period of time has elapsed, the submunition will initiate a self-destruct function. Additionally, the submunition will also self-destruct on impact. The BONUS also features a self-deactivating feature.

Nine-Step Assessment

1. **Yes.** The 155 BONUS is an artillery gun carrier projectile that releases submunitions.
2. **Yes.** The submunitions released by the 155 BONUS function by detonating an explosive charge prior to impact.
3. **No.** Neither the 155 BONUS, nor its submunitions, are designed to dispense smoke, pyrotechnics or chaff, or to generate electrical or electronic effects.
4. **No.** The 155 BONUS is used primarily in an anti-armour role.
5. **Yes.** The 155 BONUS contains two explosive submunitions.
6. **Yes.** Each BONUS Mk II submunition weighs approximately 6.5 kg.
7. **Yes.** Each BONUS Mk II submunition is designed to detect and engage a single target object.
8. **Yes.** Each BONUS Mk II submunition is equipped with an electronic self-destruction mechanism.
9. **Yes.** Each BONUS Mk II submunition is equipped with an electronic self-deactivating feature.

*Thus, the Bofors-GIAT 155 BONUS **does not** constitute a 'cluster munition' as defined under the CCM.*

Technical Specifications – 155 BONUS

Total weight: 44.6 kg
Overall length: 898 mm
Diameter: 155 mm
Number of submunitions: 2

Figure 4.12 *155 BONUS projectile (left) and container cylinder (right) (source: Nexter Munitions/BAE Systems Bofors).*

Technical Specifications – BONUS MK II submunition

Total weight: 6.5 kg
Length: 82 mm
Diameter: 138 mm
Sensors: dual-band IR; LADAR

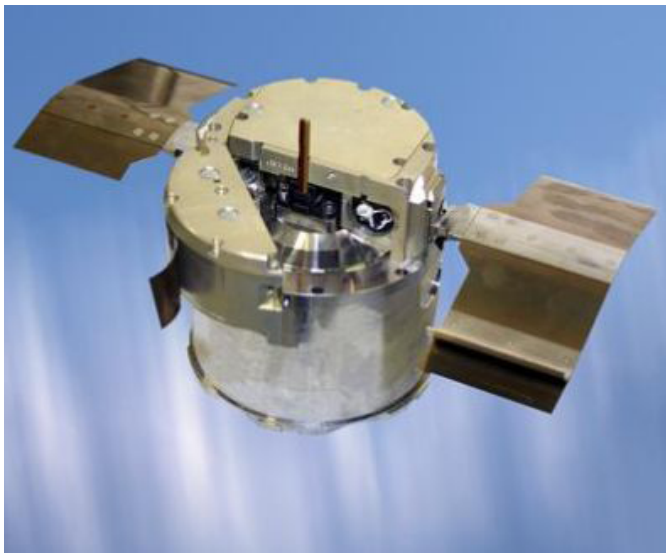

Figure 4.13 *BONUS MK II submunition (left) and BONUS Mk II electro-optical unit (right) (source: BAE Systems Bofors).*

Analysis

Of the five munitions examined in this report, the SMArt 155, M898 SADARM, and 155 BONUS are not considered to be 'cluster munitions' under the definition incorporated in the CCM. The primary factors which set these apart from the SFW and RBK-500 SPBE series munitions and, indeed, from other munitions delivering sensor-fuzed submunitions which would be considered cluster munitions under the CCM, are the weight and number of submunitions carried. Table 1 shows the results of the nine-step test as applied to the five munitions examined for this report.

Whilst the features and functions of the submunitions themselves are the most pertinent in determining whether or not a given munition is considered a cluster munition under the CCM, it is critical to note that the CCM test applies to munitions in their entirety, not solely to submunitions. For example, whilst the 155 BONUS is not prohibited under the terms of the CCM, if ten or more of the same submunitions were loaded into an aerial bomb, the resultant munition would fall foul of the CCM prohibitions. Conversely, the existing 9M55K1 rocket dispensing five SPBE-D submunitions would not be considered cluster munitions under the CCM definition. If a carrier munition is in violation of the CCM, its submunitions may nonetheless be adapted for different roles if they are themselves permissible, with the resultant munition then separately assessed as being either prohibited or not prohibited by the CCM. The permissibility of any derived cluster munition will be based predominantly on the number of submunitions it carries. However, the weight of the submunitions and other factors may also need to be considered. As noted above, even a single air-delivered BLU-108, independent of the SFW carrier munition, would constitute a cluster munition under the CCM, as each Skeet submunition weighs less than four kilograms. It is also important to note that the CCM does not mention the accuracy or precision of the carrier munition at all. Whilst the CBU-105 is a precision guided munition, for example, the other models of cargo munitions examined in this report are not.[17] Despite being prohibited under the CCM, the CBU-105 is certainly the most precise delivered munition of those assessed within this report.

The CCM does not prohibit the use of incendiary submunitions, provided these are not "designed to function by detonating an explosive charge prior to, on or after impact". Weapons such as the Russian 9M22S 122 mm rocket, which ejects some 180 individual incendiary elements over the target area, are not covered by the CCM, although they are properly considered carrier munitions (Lyamin & Smallwood, 2014). However, some NGOs and other organisations have incorrectly considered other cargo munitions which primarily deliver incendiary effects to also be permitted. For example, the Russian RBK-250 ZAB-2.5 delivers 48 incendiary submunitions of three different variants. Variant 1 is a simple thermite type submunition, and would not contravene the CCM. Variants 2 and 3, however, both contain PETN bursting charges.[18] As such, later variants of the RBK-250 ZAB-2.5 are considered cluster munitions under the CCM. Russian and Chinese incendiary weapons remain poorly understood by humanitarian organisations in general, and this area deserves further study.

The CCM also does not prohibit the use of munitions delivering dispersed non-energetic payloads. Examples of such munitions would include non-energetic payloads which are delivered en masse from aerial dispensers or cargo munitions, and which may have wide-area anti-personnel effects. The Vietnam-era Mk 44 dispenser, known as a 'missile cluster adapter' could release as many as 17,500 Lazy Dog free-fall 'aerial darts'.[19] Each Lazy Dog was only some 45 mm in length, but struck its target with considerable kinetic

[17] The RBK-500U is a guided weapon.

[18] Variant 3 also contains a jellied fuel mixture. See Jenzen-Jones, 2015b for further details.

[19] Solid metal objects, shaped like a miniature aerial bomb, and lacking both propulsion and guidance.

energy when dropped from high altitude. A similar concept is evidenced by the modern U.S. CBU-107 munition, which dispenses a mix of steel and tungsten rods of different sizes and weights,[20] which are dispersed at a height of 1500 ft and can strike targets within a 33 m diameter coverage area at speeds of up to 275 m/s (Sega, 2003).

Table 5.1 — Tabulated nine-step assessment of selected munitions employing sensor-fuzed submunitions, testing compliance with the CCM

Munition	SFW	SMArt 155	RBK-500 SPBE-D	M898 SADARM	155 BONUS
1. Does the munition in question disperse or release submunitions or bomblets?	YES	YES	YES	YES	YES
2. Are these submunitions or bomblets designed to function by detonating an explosive charge prior to, on or after impact?	YES	YES	YES	YES	YES
3. Is the munition or its submunitions or bomblets using an explosive charge in a manner designed to dispense flares, smoke, pyrotechnics or chaff, or to generate electrical or electronic effects?	NO	NO	NO	NO	NO
4. Is the munition designed exclusively for an air defence role?	NO	NO	NO	NO	NO
5. Does the munition contain fewer than ten explosive submunitions or explosive bomblets?	NO	YES	NO	YES	YES
6. Do each of the explosive submunitions or explosive bomblets weigh more than four kilograms, but less than twenty?	NO	YES	YES	YES	YES
7. Is each explosive submunition or explosive bomblet designed to detect and engage a single target object?	YES	YES	YES	YES	YES
8. Is each explosive submunition or explosive bomblet equipped with an electronic self-destruction mechanism?	YES	YES	YES	YES	YES
9. Is each explosive submunition or explosive bomblet equipped with an electronic self-deactivating feature?	YES	YES	YES	YES	YES
Is the munition considered a cluster munition under CCM?	YES	NO	YES	NO	NO

[20] 362 'large' rods, 1004 'medium' rods, and 2406 'small' rods (Sega, 2003).

Conclusion

Munitions employing sensor-fuzed submunitions have unquestionable military utility, and may also limit collateral harm to civilians and civilian objects. One way this may be achieved is by relying less on the total weight of fire from artillery systems or aircraft. This effect could be especially pronounced in urban areas. According to, Colonel Thomas G. Torrence and Lieutenant Colonel Noel T. Nicolle, two senior officers from the U.S. Army's 3rd Division Artillery who employed the M898 SADARM projectiles in Iraq in 2003, "SADARM was so effective that maneuver commanders asked to use it to destroy stationary vehicles rather than using massed artillery". They also noted the drawbacks of traditional 'dumb' dual-purpose improved conventional munitions (DPICM) submunitions, which, unlike sensor-fuzed submunitions, generally do not automatically self-destruct or disarm, saying "When the division entered the Baghdad area, HE consumption doubled because of the concern with dud-producing munitions" (Nicolle & Torrence, 2003). SMSgt Knight, the JTAC who employed 16 CBU-105 munitions in 2003, noted "a lot of times, CBUs[21] cannot be used on the ground when you're going to have follow-on friendly forces go through the area because of the dud rate… we felt very comfortable [with] the CBU-105, having a zero dud rate"[22] (Textron, n.d.).

It is reasonable to suppose that, if the number of submunitions contained within a given munition is limited by international convention, more munitions of that type may need to be employed in order to effect the same outcome. Logistic, economic, and tactical implications aside, this may also increase the risk of inaccurate or imprecise delivery, or incorrect functioning due to operator error. The possibility that this could further endanger civilians or civilian objects has been raised by many, including, for example, the U.S. DoD which said: "[B]lanket elimination of cluster munitions is unacceptable due not only to negative military consequences but also due to potential negative consequences for civilians. Large scale use of unitary weapons, as the only alternative to achieve military objectives, could result, in some cases, in unacceptable collateral damage and explosive remnants of war issues" (Gates, 2008). This statement is particularly meaningful when comparing unitary munitions or conventional 'dumb' cluster munitions to those delivering sensor-fuzed submunitions.

Some observers have noted that the number and weight of submunitions delivered by a carrier munition are largely arbitrary within the context of the CCM, since "neither of these factors can be shown to avoid indiscriminate area effects nor to reduce the risks of unexploded submunitions" (McGrath, 2009). Rather, it is the presence of advanced electronic self-destruction and self-deactivation features that dramatically reduce the risk posed by UXO to the civilian populace and to friendly ground forces. The U.S. position that, from 1 January 2019, U.S. forces will only employ cluster munitions containing submunitions that, after arming, do not result in more than one per cent UXO is a step towards civilian protection that is likely to have positive impacts whilst acknowledging the military utility of cluster munitions (Gates, 2008). Many munitions employing sensor-fuzed submunitions will incorporate further mechanisms to limit civilian harm by also offering a level of distinction between civilian and military vehicles. Whilst most extant examples of these weapons have only a limited ability to differentiate between military and civilian vehicles, improvements continue to be made in more recent models (GICHD, 2009). An enhanced ability to distinguish between legitimate targets and civilians does not remove the need for careful collateral damage estimation and correct pre-employment training, positive target identification, and use consistent with ROE and LOAC. When employed with the same care as any other munition, resultant collateral damage to civilians within the target area is likely to be lower than for other munition types.

[21] Used as shorthand for 'cluster munitions', rather than the CBU-105 specifically.

[22] It is clear from available evidence of real-world use that the CBU-105 does not have a "zero dud rate".

Broadly speaking, EOD experts agree that sensor-fuzed submunitions pose a significantly lower UXO risk than conventional submunition designs. Clearly this will vary by system, but those experts with first-hand experience in handling unexploded submunitions from the SFW, for example, have judged them to be "orders of magnitude safer than other types of sub[munition]s". Of course, all UXO remains dangerous—and there are indications that the claims made by some manufacturers regarding expected UXO ('dud') rates under testing conditions may not equate with battlefield performance. It is also important to note, however, that product improvement programmes have been undertaken for all of the munitions addressed herein. A drawback to the much higher level of safety exhibited by many of these weapons is that UXO submunitions may be more readily collected and repurposed by enemy forces, especially non-state armed groups. IEDs making use of relatively crude EFPs have caused proven a significant force protection issue for modern armed forces operating in Afghanistan, Iraq, and Yemen, and are likely to pose a particular concern. Jabhat al-Nusra has already issued video guidance indicating the value of repurposing submunitions, including SPBE sensor-fuzed submunitions in Syria which failed to function (Fulmer, 2015). When and how a submunitions self-destruct mechanism functions may also be of concern. Questions as to how the submunition warhead functions during the self-destruct process need to be answered. For example, does the EFP warhead function as designed, even if no suitable target is detected? What happens if an EFP warhead is not orientated towards the target area? The effects of operator error—particularly in employment—must also be considered.

Figure 6.1 *The future of sensor-fuzed submunitions will likely include a robust naval-attack capability (source: Textron Systems).*

[23] Correspondence with confidential EOD sources.

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